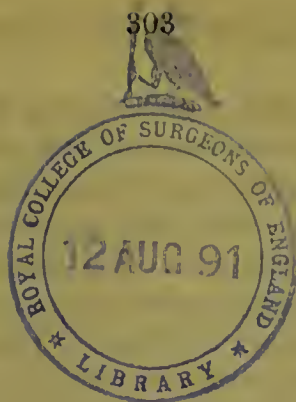


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IDENTIFICATION BY FINGER-TIPS

EVERY one bears on his body a visible token of identity which has the unique value of persisting throughout his whole life. It apparently becomes fully defined some three months before his birth, and it remains unaltered after his death until the final stage of corruption. This token of identity lies in the system of ramification of the minute ridges that run across the palms of the hands and the soles of the feet, and it more especially resides in the scrolls or other patterns that the ridges form on the inner surfaces of the bulbs of the fingers. Attention will be directed almost exclusively to the latter in these pages, as they are amply sufficient in themselves for purposes of identification, while they are easy to print from and are conveniently isolated.

The utility of a sure means of identification cannot be doubted, if it admits of being easily applied to show either (1) that a man is the person he professes to be, or (2) that he is not the person whom he is suspected to be, or (3) that he is or is not included among the persons whose names and tokens are to be found in any given register. In criminal investigations the existence of such a method would settle questions of personation, of mistaken identity and of previous conviction. In the army and navy it would afford a sure means of convicting deserters and be a powerful deterrent from desertion. It would supply an invaluable adjunct to a severe passport system. It would be of continual good service in our tropical settlements, where the individual members of the swarms of dark and yellow-skinned races are mostly unable to sign their names and are otherwise hardly distinguishable by Europeans, and, whether they can write or not, are grossly addicted to personation and other varieties of fraudulent practice.

There remain other cases, that occur rarely, but when they do occur, are of sufficient importance to make it well worth the while of persons about to emigrate to take the small trouble of leaving their finger-prints behind them as a token of their identity. For in a large population like ours, whose members migrate to all quarters of the earth, the instances are numerous of men who, having left

their homes in youth, find a difficulty on their return after many years, in proving claims to kinship and property. Or some alien scoundrel from foreign parts may assert himself to be the long-lost rightful claimant to an estate held in previous security by others on the supposition of his decease. Lastly, the important need often arises of performing the gruesome task of placing data on record that might afterwards serve to identify the unknown victim of an accident, as of the stranger who dies in hospital of a wound that left him speechless, of bodies washed up after a wreck, or of the other ghastly contents of a Morgue. If, then, a practical method could be devised which would be applicable to such cases as these, it would be of real value.

I shall in these pages describe one which I profess to be workable at once, even in its present comparatively crude form. I have no doubt that the experience of others would suggest improvements in details that have not as yet occurred to myself, though I have given a great deal of time to the subject and made a large number of experiments, and my own collection of analysed finger-prints now consists of many thousand specimens. I must now explain the nature of the markings of the fingers which appear in the prints about which I am writing. Then I must adduce evidence of the extraordinary persistency that is claimed on their behalf. Next I have to show the way of comparing two finger-prints in order to ascertain whether or no they were made by the same finger of the same person. After this I must describe how a pattern may be expressed by numerals with sufficient precision to sort it under its right heading. Lastly, I have to explain the best way of obtaining impressions from fingers, and to point out the professional persons who are well qualified and most likely to make it their business to take finger-prints and to preserve copies of them. Every one of this long list of requirements has to be fulfilled in a practical and efficient manner, otherwise there will be a weak link in the system as a whole, and it will fail to hold together. Finger-prints have been proposed over and over again before now as a means of identification, but no method of employing them has ever become definitely established, owing, as I believe, to failure in fulfilling these many requirements. No trustworthy evidence of their life-long persistence had ever been brought together and published, until by myself in a memoir read before the Royal Society some months ago (*Phil. Trans.*, 1891). No investigation had been made into what points are and are not suitable for comparison. No method of sorting patterns under heads had been brought forward that is comparable in its simplicity and exactitude with that which will be treated of here. It was communicated by me in a second short memoir read very lately before the Royal Society, and will soon appear in its Proceedings. Even the way by which finger-prints might be professionally made had not been thought out.

M. Alphonse Bertillon assures me that he does not use finger-prints in connection with his system of anthropometrie identification which is now employed in the French criminal service. The often-repeated tale of its use in the prisons of China is baseless, so far as I can learn after repeated inquiries, or, if it is not entirely baseless, it certainly rests on a very limited foundation that I have not yet succeeded in discovering. The only person who has used the method on a large scale as a check against personation by natives, is Sir William J. Herschel, during the tenure of his magistracy in Bengal, which commenced between thirty and forty years ago. I am beyond measure indebted to the finger-prints collected by him there and subsequently, which have been minutely compared by myself with other finger-prints taken recently from the same persons. He has supplied me with all the material I possess for inquiring into the question of persistence, except one couplet, which consists of a set of impressions taken by a friend of mine from his own fingers seventeen years ago in sealing-wax and accidentally preserved, and of a similar set taken a few months since. Without the help of Sir W. J. Herschel I could not have planted my first step. Moreover, the quasi pocket apparatus that I employ for taking finger-prints is the same in its essentials as one that he recently devised and I copied.

The patterns (see Fig. II.) are formed by the convolutions of delicate ridges, each of which is seen to be studded with small holes, which are the open mouths of ducts issuing from perspiratory glands. As a rule the issues of all ducts are surrounded by slight elevations of the skin, but those on the inner surface of the hands and feet have the peculiarity of not being contained in separate elevations like craters in isolated cones, but of occurring along ridges, like the craters which stud the crest of some long mountain-chain. The ridges are based in a curious way, which I must not stop to describe, upon the subcutaneous papillæ in which the ultimate organs of touch are enclosed. The ridges seem to me to act in a somewhat analogous way to the whiskers of a dog or cat. A slight pressure at the end of a hair in the whisker causes a forcible pressure at the side of the sheath that holds it, which is easily felt. So the ridges engage themselves in the roughnesses of the surface that we explore by rubbing it with the fingers, as is our wont, and the result is to forcibly affect the organs of touch which lie below and to cause a sort of thrill, which varies according to the degree of roughness and enables us to discriminate it. We learn very little indeed of the nature of a surface by merely pressing the finger upon it; the ridges do not then come into play in the way I have described.

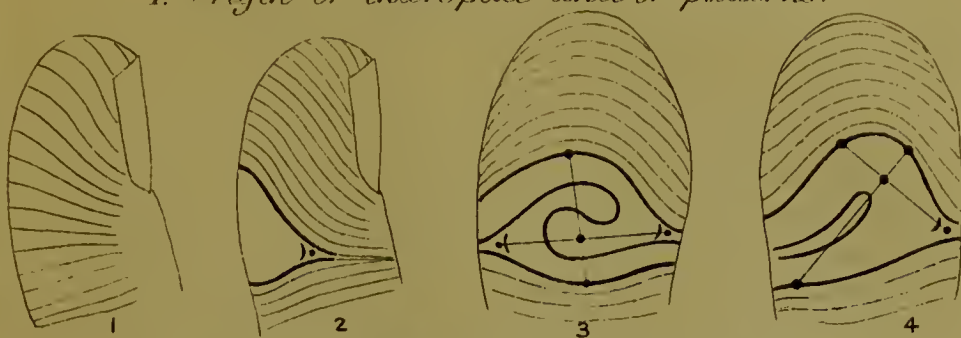
The reason why patterns exist in the bulbs of the fingers is to be found in the presence of the finger-nail. If it were not for the finger-nail, the ridges would run athwart the fingers up to its very tip, just as they do below. But the nail disturbs their parallelism,

and squeezes them downwards at either side of the finger (Fig. I., 1, 2). Consequently the ridges that run close to the tip are greatly arched; those that successively follow are gradually less so, until in some cases (Fig. I., 1) the arch insensibly disappears about the level of the joint. Usually, however, the gradual transition from an arch to a straight line fails to be carried out, and there is a break in the sequence, and a consequent interspace (Fig. I., 2, 3, 4). The uppermost boundary of the interspace is formed by the lowermost arch, and its lowermost boundary is formed by the uppermost straight ridge. The same number of ducts exist within the interspace as are to be found elsewhere in an adjacent area of equal size, and their mouths require somehow to be supported and connected. This is done by an independent scroll-work of ridges, which forms the pattern (Figs. I. and II.).

Without a knowledge of these conditions, the pattern appears to be an intricate and undefined maze, as difficult to comprehend and to describe as are the ripple-marks on seasand. But as soon as the outline of the interspace is perceived, the confused effect suddenly disappears and is replaced by one of orderliness. The first thing that the eye should do in scrutinising a pattern is to satisfy itself generally as to this outline. The core is an untrustworthy guide.

The existence of an interspace implies the divergence of two adjacent ridges on one side at least of the finger, in order to embrace it. Just in front of the place where divergence begins, and before the sweep of the pattern is reached, there is usually a very short cross-ridge. Its effect is to complete the enclosure of a minute triangular plot, which affords a valuable position or rough point of reference. When there is a plot on either side of the finger, the line that connects them (Fig. I., 3) affords a base-line whereby the pattern may be oriented and the position of any point in it can be charted. If there be a plot on one side only (as in Fig. I., 4) the pattern has almost necessarily an axis which serves for orientation, and the pattern can still be charted, though on a different principle and in the way there shown. I shall not further pursue here the subject of charting. It is gone into at length in the memoir mentioned above, and is shown to lead to curious results which do not concern us now. What has been already said was merely to show the possibility of describing the position of any remarkable peculiarity by reference to the base-line and again to the outline of the interspace. The reason why I refrain here from making an exact use of the outline is that in such finger-prints as we are usually likely to deal with, the points of reference are often absent and can only be supplied inferentially. To ensure their being printed, the finger must be somewhat *rolled*, and not simply dabbed down as in the case of Fig. II. Although no exact use can be made in such cases of the outlines, an assurance of their existence and the possibility of roughly inferring the position of the

I. Origin of interspace and of patterns.



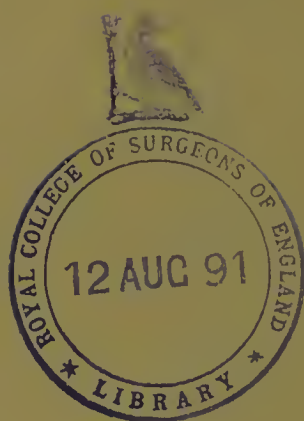
II. Persistence of Minutiae during 28 years.



in 1888. W.J.H. 1st finger of right hand in 1860.

III. Illustrations of the three fundamental forms.

<i>Whorls.</i>		<i>Primaries.</i>	<i>Loops.</i>	
<i>Nascent Whorl.</i>		<i>Parent Form.</i>	<i>Nascent Loop.</i>	



points of reference must always be borne in mind. The character of the pattern then becomes more clear, and it can be easily oriented. As soon as we are familiar with this way of viewing patterns, we rest satisfied that we have in all cases to deal with figures that are in reality sharply defined, and not with an undefined maze of ramifications and twists. I give a few specimen-outlines in Fig. III., to which I shall recur later on.

When a finger or a finger print is scrutinised under a lens, even of low power (I commonly use my eyeglasses as well as my spectacles, both of which are 12-inch focus, in place of a lens, putting them on together), it is seen to abound in minute peculiarities, due to the branchings of existing ridges and to the abrupt interpolations of new ones. It is in these minutiae, as well as in the general character of the pattern, and *not* in the measured diameters of its outline, in which the extraordinary persistence resides on which I am about to speak. The pattern grows together with the finger, and its proportions vary with fatness or leanness, and are further deformed by usage, gout, and age, which make the hands of old people less slightly than those of young ones. But, though the pattern as a whole may become considerably altered in length or breadth, the number of ridges that concur in forming it, and their embranchments and other minutiae, remain unchanged. So it is with the pattern on a piece of lace. The piece as a whole may be stretched in one way and shrunk in another, and its outline may be much changed; nevertheless, every one of the threads of which it was made, and every knot in each thread, can be easily traced. The stretchings and shrinkages draw adjacent threads slightly apart here and bring them closer together there, but those that were adjacent at the beginning remain so to the end. Not a stitch disappears, and not a stitch is added. Therefore, in speaking of the persistence of the marks on the finger, the phrase is intended to apply partly to the general character of the pattern but principally to the minutiae, and not to the measure of its length, breadth, or other diameter, which are no more constant than the stature or any other ordinary anthropometric datum.

A small reservation will have to be made, but we must first show more clearly what these minutiae are. The enlarged prints of the first finger of the right hand of Sir W. J. Herschel, made in 1888 and previously in 1860 (Fig. II.), will serve as a text. The originals of these prints were shown by me at a Friday evening lecture on 'Personal Identification' before the Royal Institution in 1888. An enlargement of them by a photographic printing process to double their size was printed both in *Nature* and in the *Transactions* of the Royal Institution. It came out well in sharp blacks and whites, so I selected it for a second double enlargement to illustrate the present pages, rather than any other of the couplets of original impressions of which I shall speak. Every one of the corresponding minutiae now

bears the same numeral in either print, and I have marked twenty-four of them altogether. Had space permitted I could have added a few more.

A new ridge is seen to be suddenly interpolated at 3, 7, 8, 9, 17, and elsewhere. An existing ridge is seen to bifurcate at 10, 15, 16, 24, and elsewhere. But, and here comes in the small reservation, an interpolation in the one may be represented by a fork in the other, as is seen clearly at 1 and in the small enclosures 4 and 5. In 4 the upper limb of the enclosure is a fork on the right side and open on the other, in the print of 1860, but not so in that of 1888; in 5 the difference between the two is still more marked. The reservation is that we must not be too particular about the apparent way in which a new ridge first arises. It may seem to be a fork or not, according to the depth of the printing, or owing to some minute alteration in the level of the ridge at its neck. The primary point is to assure ourselves of the place where a new ridge first makes its appearance; how it does so is a matter of secondary importance.

It is well worth while to carefully study these two prints, as they can tell much. We see that the lateral extension of the print made in 1888 is considerable, especially about the core, while every ridge which appears in the print of 1860 remains unchanged, and every peculiarity in each ridge remains unchanged also. The latter impression is also coarser and more worn than the earlier one. When searching for purposes of identification, a large number of prints that fall under the same general heading such as will be hereafter described, and that have a generally similar appearance, the quickest process is to fix on any one noticeable peculiarity in any one finger, such as 5 in Fig. II., and to confine the attention in the first instance solely to this, passing print after print successively under the lens to look for it, and taking a second test-point, such as 6, whenever the 5 test seems to be satisfied. A complete analysis can subsequently be made for satisfactory proof of identity.

I cannot in these pages adduce further evidence of the persistence of minutiae, but must refer the reader to the memoir already mentioned, where he will find the photo-lithographs of eight couplets, including an equivalent to the present one, in which the second impression was made in 1890, not 1888. Those eight couplets yielded an aggregate of 296 points of comparison and *every one of them was found to hold good*. Since writing that memoir I have been able to examine many other couplets, and now possess those of one, two, or more fingers, and in some cases of the whole hand, of fifteen different persons. Among the couplets that I have analysed minutely, and usually after great enlargement, are the four right-hand fingers, and the ball of the thumb of the same person when he was a child of $2\frac{3}{4}$ years, and again when he was a boy of 15; the finger-prints of three persons when they were boys or girls, and again after about seven years in their early man or

woman hood; the fingers of many persons when they were between the ages of 25 and 30, and again between those of 50 and 60. Lastly, the fingers of one man aged 63 and again when close upon 80. The total number of minutiae thus compared amount to many hundreds, and in all this multitude I have found only one failure: it was in the first case, where the forked portion of one ridge in the child of $2\frac{3}{4}$ had become fused together by the time he was a boy of 15. At first, pains and patience were often required to thoroughly unravel the impressions, especially when they were partly blotted or imperfect, but the confidence that was soon acquired through experience greatly promoted the quickness of work.

For purposes of registration and reference, the finger-prints must be classified in some ready and sure way under their appropriate headings. After a great many trials, I have come decidedly to the conclusion that the most practical way is to base the method on a few easily recognised differences of pattern in each of the ten digits and not on many minute peculiarities in a single digit. The utility of the latter method is felt in a later stage and in the way already described. Almost every pattern can be sorted without hesitation under one of the three fundamental heads of Primaries, Whorls, and Loops (Fig. III.). Those few that cannot, may be judiciously forced to do so, just as the names of foreign places have somehow to be consistently expressed by the letters of the English alphabet. A system of expression has to be adopted and rendered generally intelligible by means of a small collection of standard instances. I will speak further on of transitional cases. We have thus far specified three fundamental distinctions, but every pattern that has an axis or a tail to it must be sloped, and there are only two possible slopes. The usual slope is from below upwards and inwards. The unusual or abnormal slope is from below upwards and outwards. This rule applies equally to both hands, either to the prints made from them or to the markings in the hands themselves. The words 'right' and 'left' are wholly inappropriate here. As each of the three fundamental patterns has two varieties, we thus obtain six possible headings, which are those that I use. A Primary is numbered 1 or 2 according to its slope, if any; a Whorl, 3 or 4; a Loop, 5 or 6. Abnormal slopes have the even numbers. Normal slopes and symmetrical patterns all have the odd numbers.

Again, for reasons of convenience, partly regarding the more limited number of digits that I use for hereditary and racial inquiries, I find it best by far not to enter the index-numbers appropriate to each digit in the order in which the digits lie, either in the print or in the hand, but as follows:—first, second, and third fingers of left hand; first, second, and third of right hand; thumb and little finger of left hand; thumb and little finger of right hand. The index-number of any pair of hands consequently takes a form such as

555, 353 ; 35, 35 ; which is my own index-number ; and its print is sorted into the compartment that bears that heading.

The frequency varies greatly, with which different sequences of figures occur. I inserted a full analysis of 100 cases in the last of my two memoirs ; the commonest sequence is that where all the fingers have plain loops ; this has the index-number of 555, 555 ; 55, 55. In the 100 cases there were seventy-one separate sequences each of which occurred only once ; ten separate sequences each of which occurred only twice ; one sequence occurred three times ; and one, the above-mentioned loops, occurred six times. Hence we have

$$(71 \times 1) + (10 \times 2) + (1 \times 3) + (1 \times 6) = 100$$

The mere knowledge of an index-number that expresses the main characteristic of the pattern in each of the ten digits is therefore not to be despised. It may be compared to, though it is less exact than, the knowledge of a man's surname. If to this we add a somewhat more exact description of the several patterns as well as some one or two noticeable minutiae on the principle mentioned a few pages back, we invest the token with considerable exactitude, which can quickly be turned into moral certainty by an extension of the process.

I do not find transitional cases to give difficulty. They raise the average number of references by about one-third, and not more. In saying so I do not speak at random, but after a great deal of experiment with movable catalogues. I have now acquired much facility in reading off the appropriate index-numbers from even bad prints. My assistant, Sergeant Randall, began to succeed after the first two or three days' trial. I am sure that the proposed method lies well within the powers of an ordinary clerk, supposing him to be properly instructed. He would be a little puzzled if he had no fuller guide than this brief paper affords.

It is easy to take good prints if the proper apparatus is at hand, but otherwise it is very difficult. I use—and Hawksley, the surgical instrument maker, 357 Oxford Street, now makes and sells—a little box three and a half inches square by seven and a half long, containing a slip of stout glass, a small and good printer's roller, a collapsible tube filled with *very fluid* printer's ink, a book of blank paper, and a phial of benzole and some rags to clean the fingers. A drop of ink is squeezed out of the tube on to the glass, and is spread very evenly and *very thinly* over it by the roller. Then the fingers are lightly pressed, first on the inked surface of the glass, and afterwards on smooth paper. Finally they are cleaned. With a quasi pocket apparatus of this kind, my assistant took, in one day, the impressions of the first three fingers of the right hands of no less than 336 school children. At my laboratory, now on the point of being re-established in the western gallery of the Science Collection in South Kensington, I used a larger apparatus, consisting of a copper plate 11 by 8 inches

mounted on wood, with a printer's roller 5 inches long and 3 in diameter.

I have contrived a capital little folding-case of the size of a notebook, for occasional purposes. There are two zinc plates in it that are prevented by their frames from touching. These are blackened and will keep good for months if unopened. Only a few prints can, however, be taken from each without reblackening, but this is quickly done with the apparatus mentioned above.

The last part of our programme is to consider what professionals are likely to take to the occupation of finger-printing if a demand should arise for it, who are capable of doing it neatly and are at the same time everywhere accessible. I say the photographers. They are a class of men who are naturally gifted with dexterity of fingers, mechanical aptitudes, versatility, and some artistic taste. So far as they are engaged in portraiture, they already occupy themselves in supplying one means of identification; therefore the pursuit of another means of identification would in some sense lie within their present province. Photographers are also habituated to preserve registers and negatives of their photographs in an orderly way. Moreover they one and all crave for an extension of practice, as I judge from the letters I read in photographic newspapers. The photographers as a class would be well qualified to take finger prints neatly, which they would know how to mount artistically. They would also probably photograph the result. It is easy for them to try the process of finger printing. A piece of half-inch india-rubber tubing stretched over a wooden cylinder is a makeshift for a printer's roller that is not to be despised, and boiled or burnt linseed oil procurable at the oilman's, and mixed with a little fine soot that has collected on a plate held over a candle, makes a serviceable ink.

I look forward to a time when every convict shall have prints taken of his fingers by the prison photographer, at the beginning and end of his imprisonment, and a register made of them; when recruits for either service shall go through an analogous process; when the index-number of the hands shall usually be inserted in advertisements for persons who are lost or who cannot be identified, and when every youth who is about to leave his home for a long residence abroad, shall obtain prints of his fingers at the same time that the portrait is photographed, for his friends to retain as a memento.

FRANCIS GALTON.

